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This handbook for the port of Porto Torres, one in a series of severe weather guides for Mediterranean ports, provides decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captain's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information.

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captains whose vessels are threatened by actual or
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or thunderstorms in the port vicinity. Causes and
effects of such hazardous conditions are discussed .
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various vessel situations. The handbook is organized in
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handbook content and use; a quick-look captain's
summary; a more detailed review of general information
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Naval Environmental Prediction Research Facility
Monterey, CA 93943-5006

Contractor Report CR 89-07 June 1989

SEVERE WEATHER GUIDE MEDITERRANEAN PORTS

28. PORTO TORRES

by R. E. Engelbretson
and R. D. Gilmore

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FOREWORD

This handbook on Mediterranean Ports was developed as part of an ongoing effort at the Naval Environmental Prediction Research Facility to create products for direct application to Fleet operations. The research was conducted in response to Commander Naval Oceanography Command (COMNAVOCEANCOM) requirements validated by the Chief of Naval Operations (OP-096).

As mentioned in the preface, the Mediterranean region is unique in that several areas exist where local winds can cause dangerous operating conditions. This handbook will provide the ship's captain with assistance in making decisions regarding the disposition of his ship when heavy winds and seas are encountered or forecast at various port locations.

Readers are urged to submit comments, suggestions for changes, deletions and/or additions to Naval Oceanography Command Center (NAVOCEANCOMCEN), Rota with a copy to the oceanographer, COMSIXTHFLT. They will then be passed on to the Naval Environmental Prediction Research Facility for review and incorporation as appropriate. This document will be a dynamic one, changing and improving as more and better information is obtained.

W. L. SHUTT
Commander, U.S. Navy

PORT INDEX

The following is a tentative prioritized list of Mediterranean Ports to be evaluated during the five-year period 1988-92, with ports grouped by expected year of the port study's publication. This list is subject to change as dictated by circumstances and periodic review.

1988 NO.	PORT
1	GAETA, ITALY
2	NAPLES, ITALY
3	CATANIA, ITALY
4	AUGUSTA BAY, ITALY
5	CAGLIARI, ITALY
6	LA MADDALENA, ITALY
7	MARSEILLE, FRANCE
8	TOULON, FRANCE
9	VILLEFRANCHE, FRANCE
10	MALAGA, SPAIN
11	NICE, FRANCE
12	CANNES, FRANCE
13	MONACO
14	ASHDOD, ISRAEL
15	HAIFA, ISRAEL
16	BARCELONA, SPAIN
17	PALMA, SPAIN
18	IBIZA, SPAIN
19	POLLENSA BAY, SPAIN
20	LIVORNO, ITALY
21	LA SPEZIA, ITALY
22	VENICE, ITALY
23	TRIESTE, ITALY
24	CARTAGENA, SPAIN
25	VALENCIA, SPAIN

1989	PORT
26	SAN REMO, ITALY
27	GENOA, ITALY
28	PORTO TORRES, ITALY
29	PALERMO, ITALY
30	MESSINA, ITALY
31	TAORMINA, ITALY
	BENIDORM, SPAIN

1990	PORT
	TARANTO, ITALY
	ALEXANDRIA, EGYPT
	PORT SAID, EGYPT
	ANTALYA, TURKEY
	ISKENDERUN, TURKEY
	IZMIR, TURKEY
	GOLCUK, TURKEY
	ISTANBUL, TURKEY

1991	PORT
	ROTA, SPAIN
	TANGIER, MOROCCO
	ALGIERS, ALGERIA
	TUNIS, TUNISIA
	BIZERTE, TUNISIA
	SFAX, TUNISIA
	VALETTA, MALTA

1992	PORT
	SOUDA BAY, CRETE
	PIRAEUS, GREECE
	KALAMATA, GREECE
	THESSALONIKI, GREECE
	CORFU, GREECE
	KITHIRA, GREECE
	LARNACA, CYPRUS
	DUBROVNIK, YUGOSLAVIA
	SPLIT, YUGOSLAVIA
	GULF OF SOLLUM

PREFACE

Environmental phenomena such as strong winds, high waves, restrictions to visibility and thunderstorms can be hazardous to critical Fleet operations. The cause and effect of several of these phenomena are unique to the Mediterranean region and some prior knowledge of their characteristics would be helpful to ship's captains. The intent of this publication is to provide guidance to the captains for assistance in decision making.

The Mediterranean Sea region is an area where complicated topographical features influence weather patterns. Katabatic winds will flow through restricted mountain gaps or valleys and, as a result of the venturi effect, strengthen to storm intensity in a short period of time. As these winds exit and flow over port regions and coastal areas, anchored ships with large 'sail areas' may be blown aground. Also, hazardous sea state conditions are created, posing a danger for small boats ferrying personnel to and from port. At the same time, adjacent areas may be relatively calm. A glance at current weather charts may not always reveal the causes for these local effects which vary drastically from point to point.

Because of the irregular coast line and numerous islands in the Mediterranean, swell can be refracted around such barriers and come from directions which vary greatly with the wind. Anchored ships may experience winds and seas from one direction and swell from a different direction. These conditions can be extremely hazardous for tendered vessels. Moderate to heavy swell may also propagate outward in advance of a storm resulting in uncomfortable and sometimes dangerous conditions, especially during tending, refueling and boating operations.

This handbook addresses the various weather conditions, their local cause and effect and suggests some evasive action to be taken if necessary. Most of the major ports in the Mediterranean will be covered in the handbook. A priority list, established by the Sixth Fleet, exists for the port studies conducted and this list will be followed as closely as possible in terms of scheduling publications.

RECORD OF CHANGES

CHANGE NUMBER	DATE OF CHANGE	DATE ENTERED	PAGE NUMBER	ENTERED BY

1. GENERAL GUIDANCE

1.1 DESIGN

This handbook is designed to provide ship captains with a ready reference on hazardous weather and wave conditions in selected Mediterranean harbors. Section 2, the captain's summary, is an abbreviated version of section 3, the general information section intended for staff planners and meteorologists. Once section 3 has been read, it is not necessary to read section 2.

1.1.1 Objectives

The basic objective is to provide ship captains with a concise reference of hazards to ship activities that are caused by environmental conditions in various Mediterranean harbors, and to offer suggestions for precautionary and/or evasive actions. A secondary objective is to provide adequate background information on such hazards so that operational forecasters, or other interested parties, can quickly gain the local knowledge that is necessary to ensure high quality forecasts.

1.1.2 Approach

Information on harbor conditions and hazards was accumulated in the following manner:

A. A literature search for reference material was performed.
B. Cruise reports were reviewed.
C. Navy personnel with current or previous area experience were interviewed.
D. A preliminary report was developed which included questions on various local conditions in specific harbors.
E. Port/harbor visits were made by NEPRF personnel; considerable information was obtained through interviews with local pilots, tug masters, etc; and local reference material was obtained.
F. The cumulative information was reviewed, combined, and condensed for harbor studies.

1.1.3 Organization

The Handbook contains two sections for each harbor. The first section summarizes harbor conditions and is intended for use as a quick reference by ship captains, navigators, inport/at sea OOD's, and other interested personnel. This section contains:

A. a brief narrative summary of environmental hazards,
B. a table display of vessel location/situation, potential environmental hazard, effect-precautionary/evasion actions, and advance indicators of potential environmental hazards,
C. local wind wave conditions, and
D. tables depicting the wave conditions resulting from propagation of deep water swell into the harbor.

The swell propagation information includes percent occurrence, average duration, and the period of maximum wave energy within height ranges of greater than 3.3 feet and greater than 6.6 feet. The details on the generation of sea and swell information are provided in Appendix A.

The second section contains additional details and background information on seasonal hazardous conditions. This section is directed to personnel who have a need for additional insights on environmental hazards and related weather events.

1.2 CONTENTS OF SPECIFIC HARBOR STUDIES

This handbook specifically addresses potential wind and wave related hazards to ships operating in various Mediterranean ports utilized by the U.S. Navy. It does not contain general purpose climatology and/or comprehensive forecast rules for weather conditions of a more benign nature.

The contents are intended for use in both pre-visit planning and in situ problem solving by either mariners or environmentalists. Potential hazards related to both weather and waves are addressed. The oceanographic information includes some rather unique information relating to deep water swell propagating into harbor shallow water areas.

Emphasis is placed on the hazards related to wind, wind waves, and the propagation of deep water swell into the harbor areas. Various vessel locations/situations are considered, including moored, nesting, anchored, arriving/departing, and small boat operations. The potential problems and suggested pre-cautionary/evasive actions for various combinations of environmental threats and vessel location/situation are provided. Local indicators of environmental hazards and possible evasion techniques are summarized for various scenarios.

CAUTIONARY NOTE: In September 1985 Hurricane Gloria raked the Norfolk, VA area while several US Navy ships were anchored on the muddy bottom of Chesapeake Bay. One important fact was revealed during this incident: Most all ships frigate size and larger dragged anchor, some more than others, in winds of over 50 knots. As winds and waves increased, ships 'fell into' the wave troughs, BROADSIDE TO THE WIND and become difficult or impossible to control.

This was a rare instance in which several ships of recent design were exposed to the same storm and much effort was put into the documentation of lessons learned. Chief among these was the suggestion to evade at sea rather than remain anchored at port whenever winds of such intensity were forecast.

2. CAPTAIN'S SUMMARY

The Port of Porto Torres is located on the north coast of the Italian island of Sardinia at approximately 40°51'N 8°24'E (Figure 2-1).

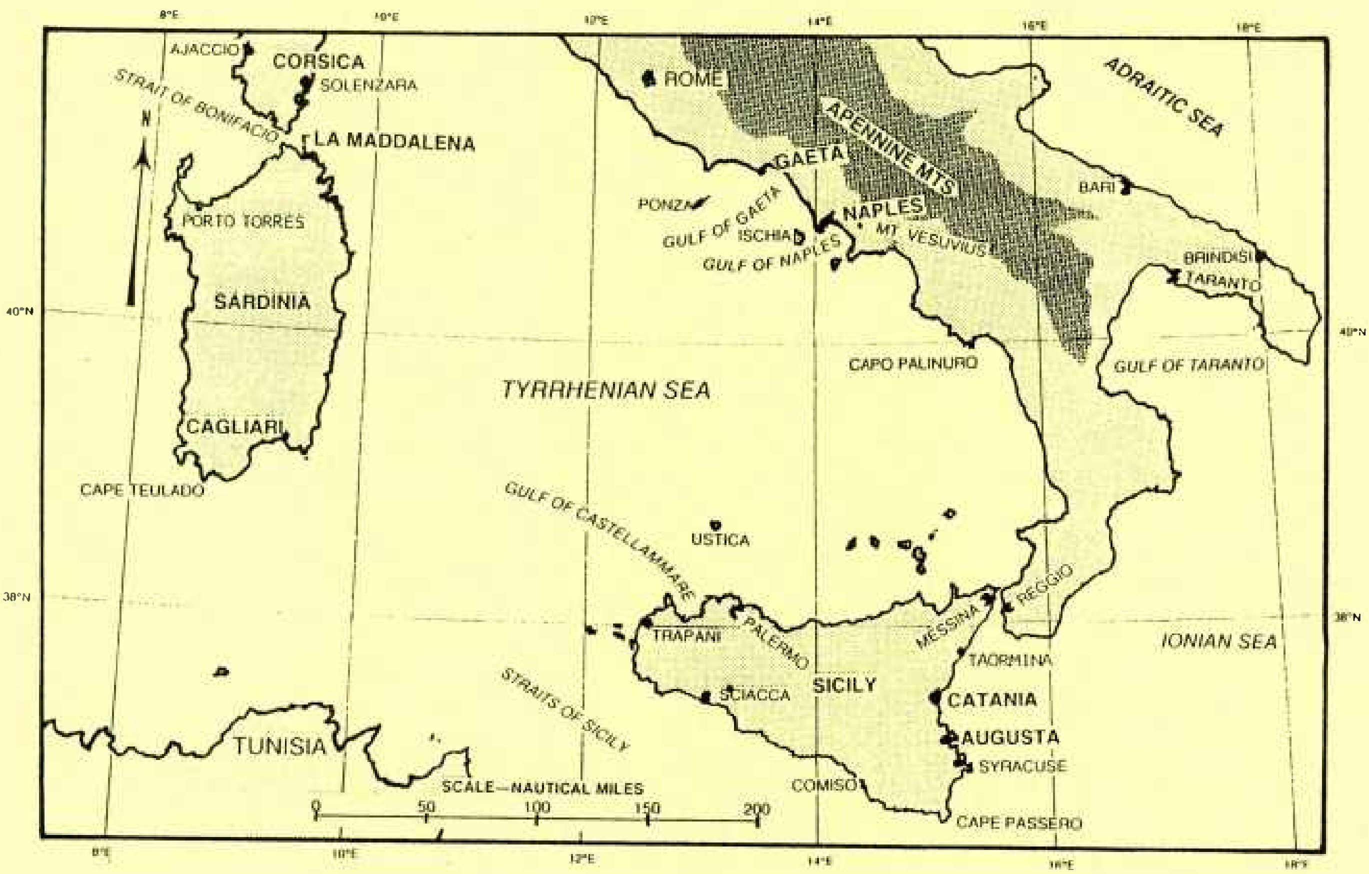

Figure 2-1. Ports of Italy, Sicily, and Sardinia.

The Port is situated on the south coast of Golfo dell' Asinara, which is formed between Asinara Island on the west and northwest and the north coast of Sardinia (Figure 2-2). Terrain near Porto Torres is generally low lying, but elevations rise to over 1,100 ft (335 m) about 5 n mi southwest of the Port.

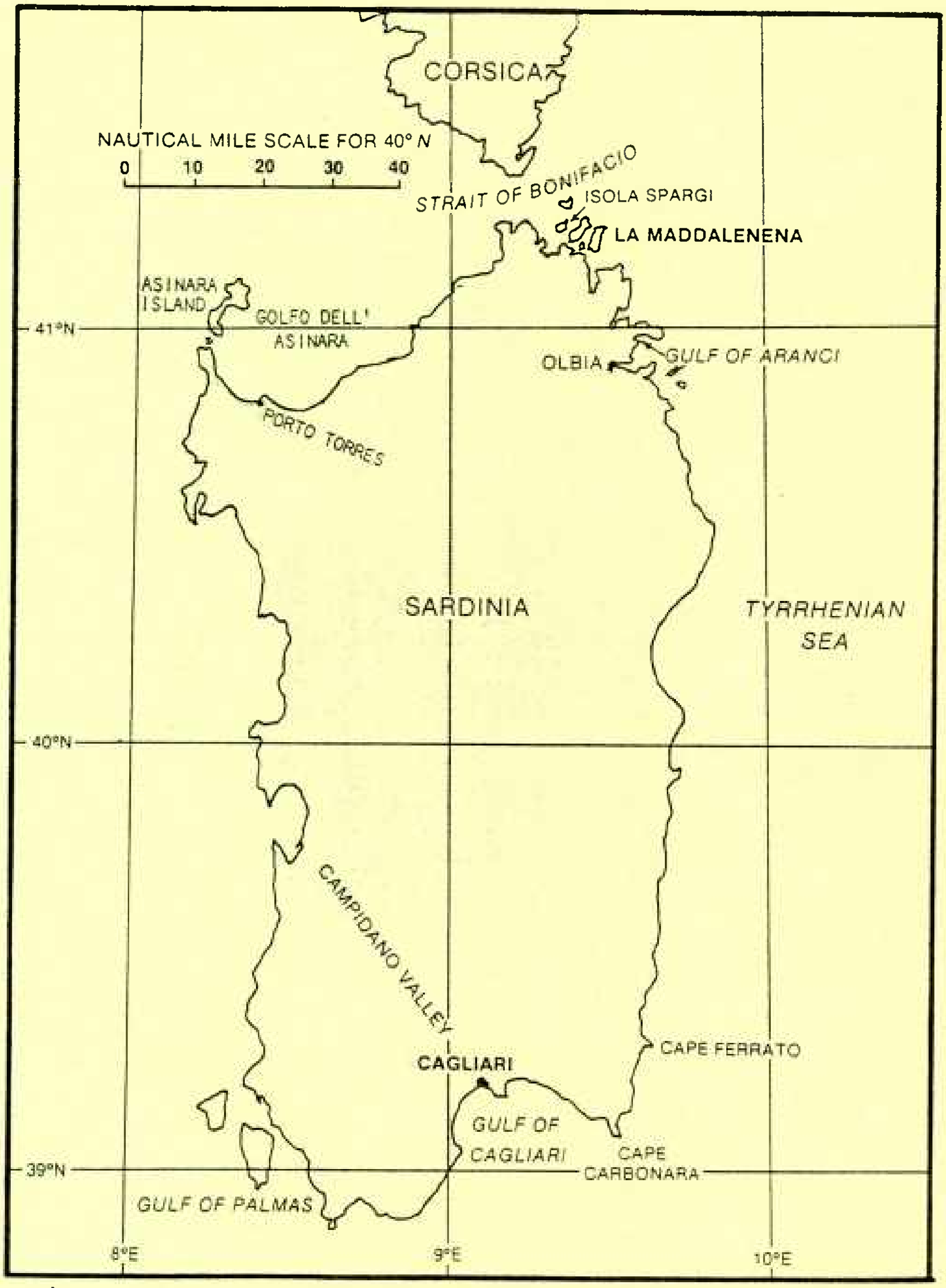

Figure 2-2. Sardinia and Surrounding Waters.

The Port is divided into two main sections, the inner harbor and outer harbor (Figure 2-3). The inner harbor (called the "Old Port") is semi-enclosed, being bounded by Molo di Ponente on the harbor's west and northwest sides and Molo di Levante on the east and northeast sides. The inner harbor entrance lies between the two moles, with an approximate horizontal clearance of about 200 yd (183 m).

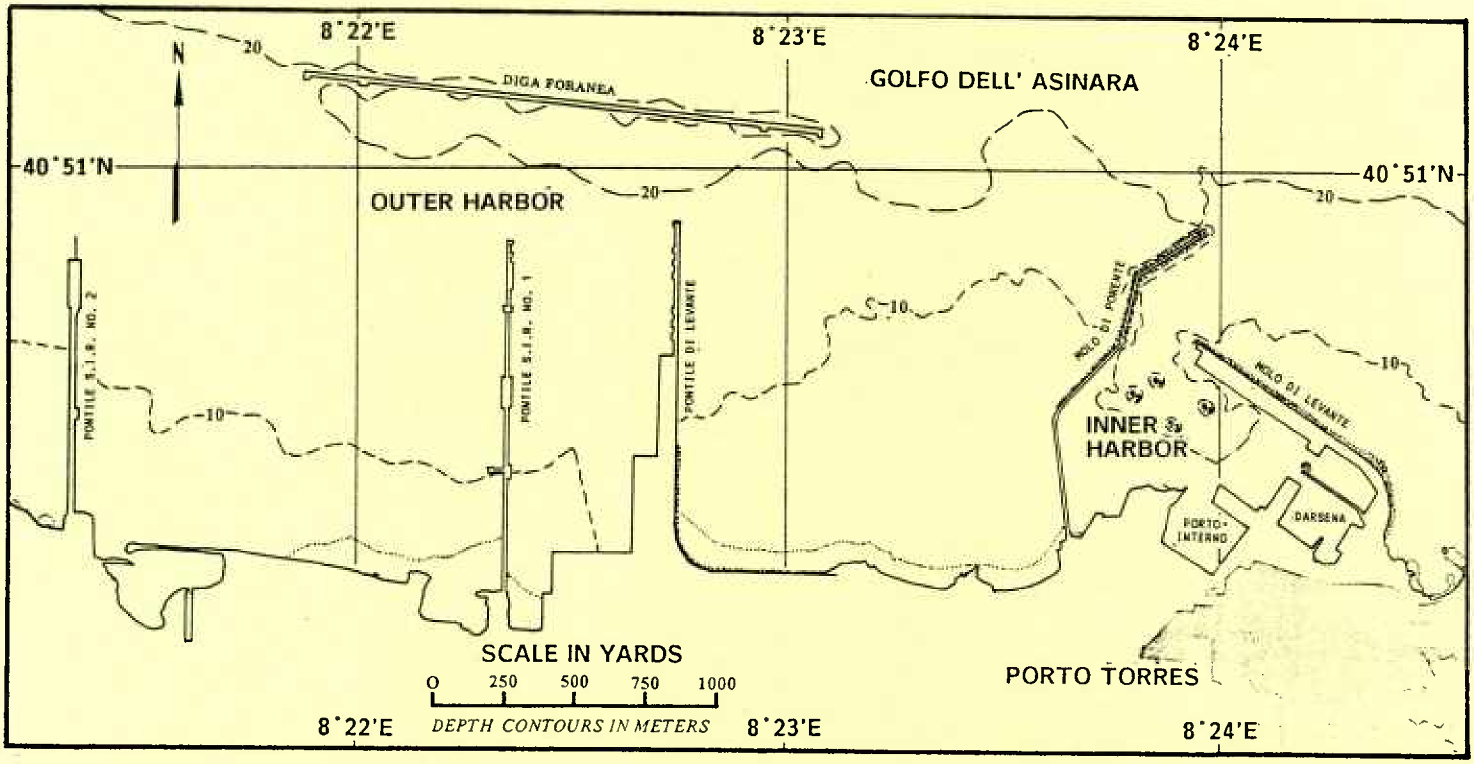

Figure 2-3. Inner and Outer Harbors of Porto Torres.

The outer harbor (called the "New Port") is located west of the inner harbor and consists of three piers. The piers, named Pontile di Levante, Pontile S.I.R. No. 1, and Pontile S.I.R. No. 2, extend about 1/2 n mi northward from the coastline. The piers are sheltered somewhat by a 1725 m long concrete breakwater, Diga Foranea, which runs roughly east-west about 900 ft north of the end of the center mole. The center mole, Pontile S.I.R. No. 1, has oil berths while the two outer most moles have cargo berths. Pontiles S.I.R. (FICEURLANT, 1987). No. 1 and 2 are built on columns, while Pontile di Levante is built on solid concrete (Port Visit, 1988).

The inner harbor is capable of accommodating vessels 394 ft (120 m) long with maximum drafts of 23 ft (7 m), while the outer harbor is capable of handling vessels to 492 ft (150 m) in length with drafts of 26 ft (8 m)(FICEURLANT, 1987). The west mole (Molo di Ponente) has tanker berths in a depth of 23 ft (7 m). The fleet landing is located at the Port Captain's red-striped building in the darsena (basin). Silting in the harbor is not a problem; Port personnel consider charted depths to be valid.

The berth which is most often used at Porto Torres is near the end of Pontile S.I.R. No. 1 in the outer harbor. It generally has depths of 30 to 49 ft (9 to 15 m), but in 1984, an AOE berthed on the east side of the seaward end of the fuel pier, portside to, bow out, and had an alongside depth of 59 ft (18 m) (FICEURLANT, 1987).

Anchorage is available for smaller vessels about 1 mi east of the green light on the head of Molo di Ponente in a depth of about 82 ft (25 m). Larger vessels anchor north of the Port in a depth of 98 ft (30 m). Both anchorages offer good holding on mud and sand bottoms, but since they are outside the protective confines of the breakwaters, they are exposed and vulnerable to winds and waves.

Local authorities state that currents are non-existent except for those which are wind driven. If a wind blows for 2 or 3 days from the same direction, a current will form, with its speed being dependent on the wind strength. Tides are negligible, with a range of less than 1 ft (0.3 m).

Specific hazardous conditions, vessel situations, and suggested precautionary/evasive action scenarios are summarized in Table 2-1.

Table 2-1. Summary of hazardous environmental conditions for the Port of Porto Torres.

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
1. NW'ly winds/waves - Locally known as Mistral, regardless of origin. * Strongest and most common during October to mid-May period. * Typical outbreak has winds of 40 kt with 70 kt maximum. * Waves in outer harbor and anchorages are typically 6 ft (2 m) with 5-7 second periods. * Waves of 15-20 ft (4.5-6m) in open sea and anchorages.	Advance warning * Low clouds usually form on the hills of Asinara Island about 24 hr prior to the onset of strong NW winds. Duration * Typical event lasts 24-48 hr, but may last longer. * Swell waves develop with a strong outbreak and may persist for up to 15 hr after winds abate, then diminish rapidly.	(1) Moored - Outer harbor.	(a) Waves cause ships moored to Pontile S.I.R. No. 1 to pound against the pier. * Ships should get underway and leave the Port prior to wind onset. * Waves near the Port entrance make entering and leaving the Port dangerous once the wind has started blowing. * There were only 2 tugs available in Porto Torres (Port Visit, 1988), and they may not be available once heavy weather sets in, so early action to leave the Port is necessary. (b) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.
		(2) Moored - Inner harbor.	(a) Winds have little effect on ships which are securely moored. * Mooring lines should be doubled. * Waves do not reach the inner harbor. (b) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.
		(3) Anchored - Outside breakwaters.	(a) The anchorages are exposed to winds and waves. * Ships in the anchorages should weigh anchor and move to the lee of Asinara Island when strong NW winds are forecast. NOTE: Anchoring near Asinara Island is normally prohibited, but the Port Captain will permit it during strong winds. (b) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.
		(4) Arriving/departing.	(a) Inbound units should be aware of the limited tug availability, as well as hazardous conditions that exist in the anchorages, at Pontile S.I.R. No. 1, and near the harbor entrance during strong wind situations. * Vessels inbound to one of the anchorages should opt for a temporary anchorage in the lee of Asinara Island until winds/waves abate. * Vessels inbound to Pontile S.I.R. No. 1 should delay arrival until winds/waves abate or choose a different moorage where pounding would not be a problem. (b) Outbound units should be aware of the limited tug availability, as well as the hazardous conditions that exist near the harbor entrance during strong wind situations. * Vessels should get underway prior to the onset of strong winds in order to avoid the worst conditions at the harbor entrance and take advantage of increased tug availability. (c) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.
		(5) Small boats.	(a) Operations in the inner harbor will be largely unaffected, but runs outside the harbor entrance should be curtailed until conditions abate. (b) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.

Table 2-1. (Continued)

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
2. NE'ly winds/waves * Most common during October to May period. * Typical outbreak has winds of 35-40 kt with 55 kt maximum. * Limited fetch NE of Porto Torres restricts wave growth.	Advance warning * NE winds may follow NW Mistral winds at Porto Torres if low pressure in Gulf of Genoa moves SE across Tyrrhenian Sea. Duration * If SE moving low stagnates W of S Italy, NE winds may blow for days.	(1) Moored - Outer harbor.	(a) Waves are blocked from reaching Pontiles S.I.R. No. 1 and 2 by the solid construction of Pontile de Levante. * Mooring lines should be doubled. (b) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.
		(2) Moored - Inner harbor.	(a) Little effect on ships which are securely moored. * Mooring lines should be doubled. (b) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.
		(3) Anchored - Outside breakwaters.	(a) The anchorages are exposed to the full force of the winds/waves, but ships may be able to remain in the anchorage. * Limited fetch (about 50 n mi) NE of the anchorage limits wave growth, so if wind limits allow, deploying 2 anchors may permit ships to remain at anchor. * If strong winds dictate leaving the anchorage, relief from the high winds/waves may be found in the lee of high terrain of Corsica or Sardinia. (b) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.
		(4) Arriving/departing.	(a) Winds/waves can create hazardous conditions near the harbor entrance. * Inbound vessels should be aware of the hazardous conditions as well as limited tug availability during strong winds, prior to committing to enter the harbor. * Outbound units should get underway prior to the onset of the wind in order to avoid the hazardous conditions near the harbor entrance. (b) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.
		(5) Small boats.	(a) Inner harbor operations should be able to continue, but runs outside the entrance to the inner harbor should be curtailed until conditions abate. (b) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.

SEASONAL SUMMARY OF HAZARDOUS WEATHER CONDITIONS

WINTER (November through February)

* Northwesterly winds: Called Mistral, even though not all northwesterly winds are of true Mistral origin. Any low moving eastward north of local region can cause northwest winds which makes entering/leaving the Port hazardous. Winds are 40 kt in a typical outbreak, although 75 kt is possible. The harbor is protected from the highest northwesterly winds by Asinara Island, but waves of 6 ft (2 m) with 5 to 7 second periods are common in the outer harbor, with 13 ft (4 m) waves possible. The inner harbor is protected from northwesterly wave motion. Mistral winds, which usually originate in the Gulf of Lion or the Rhone River Valley near Marseille, France before spreading southeastward to the Porto Torres area, are responsible for about 70 percent of "bad weather" at the Port. Low clouds usually form on the hills of Asinara Island about 24 hours prior to the onset of strong northwesterly winds.
* Northeast winds: Less common, but also a producer of hazardous conditions at the Port. A typical outbreak will have winds of 35 to 40 kt, with maximum velocities of 55 kt. The solid concrete construction of Molo di Levante effectively blocks northeasterly waves from reaching Pontiles S.I.R. No. 1 and 2. Northeasterly winds are most often caused by low pressure systems which move southeastward from the Gulf of Genoa across the Tyrrhenian Sea.

SPRING (March through May)

* Early spring conditions are much the same as winter. Most of the strongest winds are over by early May.
* Early morning visibility is infrequently (1 or 2 days each year) reduced to less than 2 miles.

SUMMER (June through September)

* Summer weather is generally good with daily weak sea breezes. Although Mistral events may occur year-round, strong winds from any direction are uncommon.

AUTUMN (October)

* Short transition season with winter-like weather returning by the end of the month.

NOTE: For more detailed information on hazardous weather conditions, see previous Summary Table in this section and Hazardous weather Summary in Section 3.

REFERENCES

FICEURLANT, 1987: Port Directory for Porto Torres (1984, reissued 1987), Italy. Fleet Intelligence Center Europe and Atlantic, Norfolk, VA.

PORT VISIT INFORMATION

MAY 1988. NEPRF Meteorologists R. Fett and D. Perryman met with the Porto Torres Harbor Office Technical Officer, Captain Nicola Del Nobile, to obtain much of the information included in this port evaluation.

3. GENERAL

This section is intended for Fleet meteorologists/oceanographers and staff planners. Paragraph 3.5 provides a general discussion of hazards and Table 3-2 provides a summary of vessel locations/situations, potential hazards, effects, precautionary/evasive actions, and advance indicators and other information by season.

3.1 Geographic Location

The Port of Porto Torres is located on the north coast of the Italian island of Sardinia at approximately 40°51'N 8°24'E (Figure 3-1).

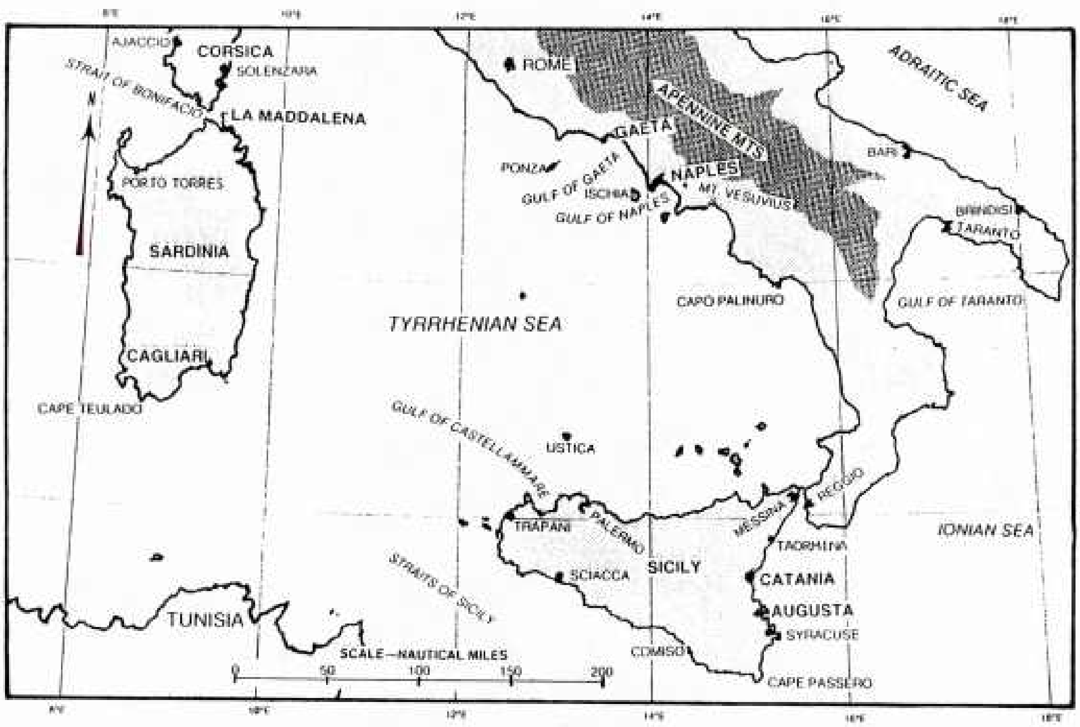

Figure 3-1. Ports of Italy, Sicily, and Sardinia.

The Port is situated on the southern shoreline of Golfo dell' Asinara. The Golfo dell' Asinara is located between Asinara Island on the west and northwest and the coast of Sardinia on the south (Figure 3-2). Terrain near Porto Torres is generally low lying, but elevations rise to over 1,100 ft (335 m) about 5 n mi inland southwest of the Port.

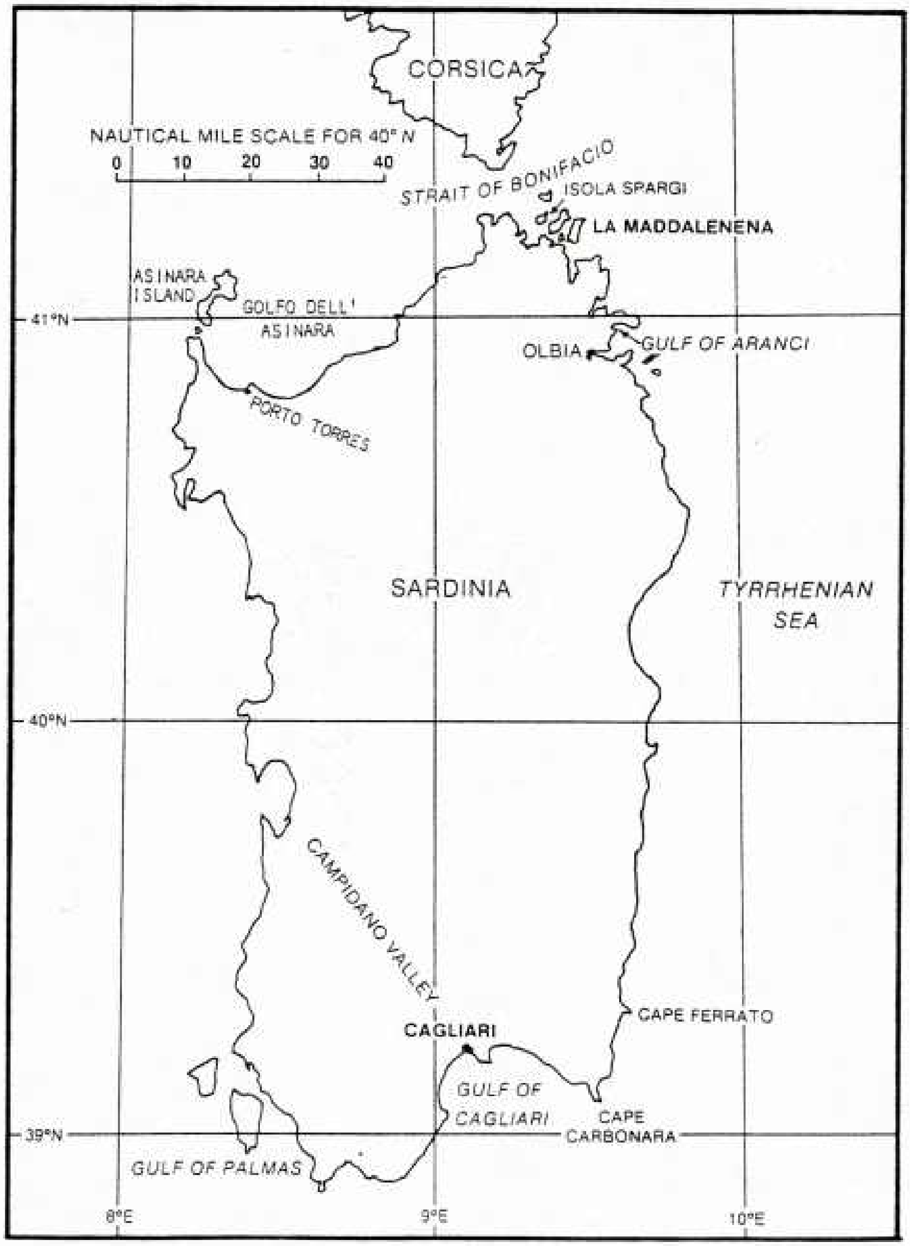

Figure 3-2. Sardinia and Surrounding Waters.

The Port is divided into two main sections, the inner harbor and outer harbor (Figure 3-3). The inner harbor (called the "Old Port") is semi-enclosed, being bounded by Molo di Ponente on the harbor's west and northwest sides and Molo di Levante on the east and northeast sides. The harbor entrance lies between the two moles, with an approximate horizontal clearance of about 200 yd (183 m).

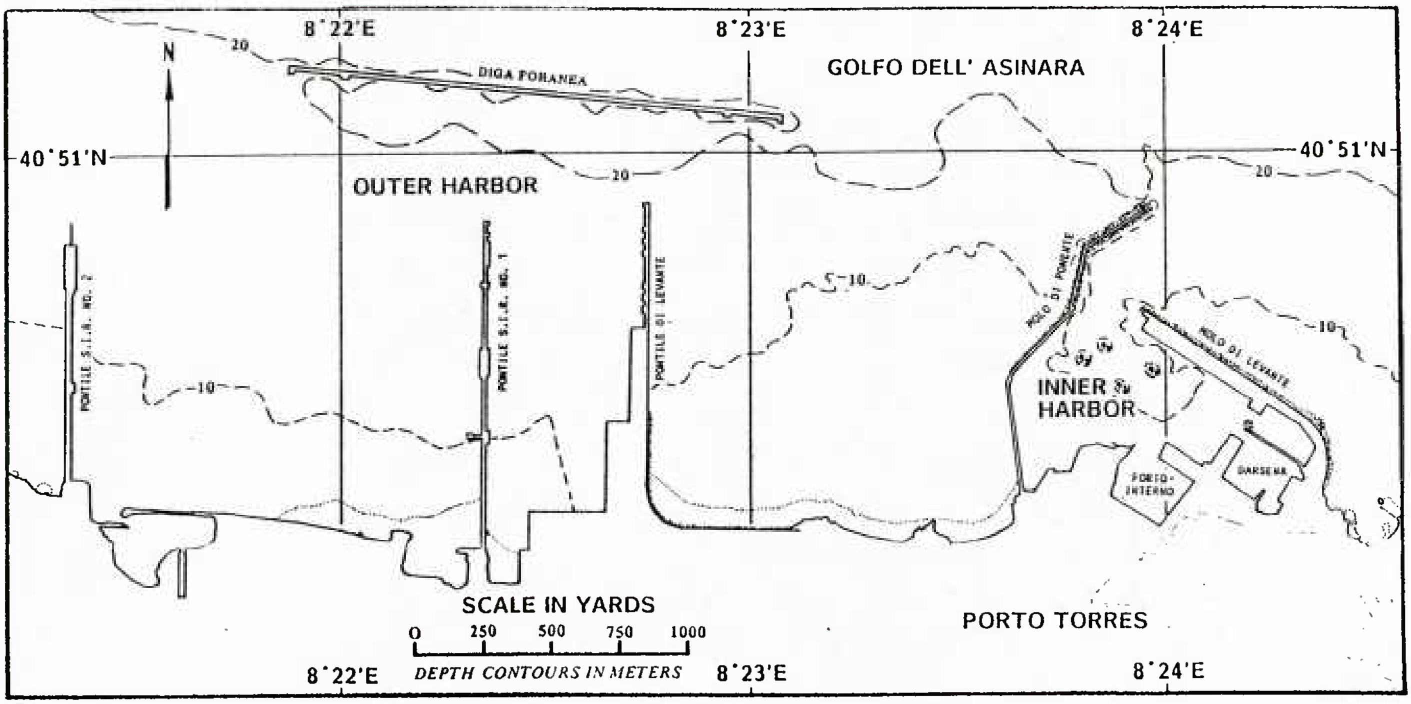

Figure 3-3. Inner and Outer Harbors Of Porto Torres.

The outer harbor (called the "New Port") is located west of the inner harbor and consists of three piers. The piers, named Pontile di Levante, Pontile S.I.R. No. 1, and Pontile S.I.R. No. 2, extend about 1/2 n mi northward from the coastline. The piers are sheltered somewhat by a 1725 m long concrete breakwater, Diga Foranea, which runs roughly east-west about 365 yd (335 m) north of the end of the center mole. The center mole, Pontile S.I.R. No. 1, has oil berths while the two outermost moles have cargo berths. Pontiles S.I.R. (FICEURLANT, 1984). No. 1 and 2 are built on columns, while Pontile di Levante is built on solid concrete (Port Visit, 1988).

The inner harbor is capable of accommodating vessels 394 ft (120 m) long with maximum drafts of 23 ft (7 m), while the outer harbor is capable of handling vessels to 492 ft (150 m) in length with drafts of 26 ft (8 m) (FICEURLANT, 1987). The west mole (Molo di Ponente) has tanker berths in a depth of 23 ft (7 m). The fleet landing is located at the Port Captain's red-striped concrete building in the darsena (basin). Silting in the harbor is not a problem; Port personnel consider charted depths to be valid.

The berth used most often at Porto Torres is near the end of Pontile S.I.R. No. 1 in the outer harbor. It generally has depths of 30 to 49 ft (9 to 15 m), but in 1984, an AOE berthed on the east side of the seaward end of the fuel pier, portside to, bow out, and had an alongside depth of 59 ft (18 m) (FICEURLANT, 1987).

Anchorage is available for smaller vessels about 1 mi east of the green light on the head of Molo di Ponente in a depth of about 82 ft (25 m). Larger vessels anchor north of the Port in a depth of 98 ft (30 m). Both anchorages offer good holding on mud and sand bottoms.

3.2 Qualitative Evaluation of the Port of Porto Torres

The inner harbor offers excellent protection from heavy weather because of the orientation of Molo di Ponente and Molo di Levante. The harbor is exposed to wind but the mole/breakwater system protects ships from most wave motion.

Although protected somewhat by the island of Asinara, the outer harbor is exposed and vulnerable to high winds and waves. The worst conditions are caused by northwesterly Mistral winds, which routinely bring winds of 40 kt and waves of 6 ft (2 m) with 5 to 7 second periods to the pier area. Maximum winds from the northwest are about 75 kt. In the open seas 15-20 ft (4.5-6 m) waves are typical during strong Mistral events.

The winds generate a heavy sea and considerable surf that makes entering or leaving the Port dangerous. The high waves cause ships berthed at Pontile S.I.R. No. 1 to pound against the pier. Leaving the port prior to the onset of strong northwest winds is recommended. Winds from the northeast, although less frequent, can also cause hazardous conditions in the Port.

The anchorages, which are outside the protective confines of the breakwaters, are exposed and vulnerable to winds and waves from the northwest and northeast. However, during strong northwest wind events anchorage in the lee of Asinara Island is allowed and this anchorage is protected from both winds and waves (Port Visit, 1988).

3.3 Currents and Tides

Local authorities state that currents are non-existent except for wind driven currents. If a wind blows for 2 or 3 days from the same direction, a current will form, with its speed being dependent on the wind strength. Tides are negligible, with a range of less than 1 ft (0.3 m).

3.4 Visibility

Visibility at Porto Torres is generally good, except that on one or two occasions per year, thick fog will reduce visibility to less than 2 miles. The reduction is usually a springtime, early morning phenomenon.

3.5 Hazardous Conditions

Most hazardous conditions are caused by Mistral (northwest) winds and occur during the winter. High winds and seas create hazardous conditions for vessels berthed in the outer harbor and during exiting or entering the harbors. Low clouds forming over the hills of Asinara Island are an indicator of strong northwesterly winds within 24 hours. Northeast winds associated with cyclones moving southeastward through the Tyrrhenian Sea can also cause hazardous winter conditions at the Port.

Although rare, storms having tropical cyclone characteristics with fully developed eyes have been observed on at least three occasions in the Mediterranean Basin: 23-26 September 1969, 22-28 January 1982, and 26-30 September 1983. On the latter occasion the storm moved northwest from the Gulf of

Gabes (on the southeast coast of Tunisia), through the Straits of Sicily, along the east coast of Sardinia, and into the Gulf of Genoa. Winds of 100 kt were observed near the eye, while Cagliari, Sardinia reported winds of 60 kt. The location of Porto Torres on the western part of the north coast of Sardinia makes the probability of damaging winds from such a storm reaching Porto Torres extremely remote, but the meteorologist must be aware of the possibility.

A seasonal summary of various known environmental hazards that may be encountered in the Port of Porto Torres follows.

A. <u>Winter (November through February)</u>

Mistral winds are responsible for about 70 percent of the "bad weather" at Porto Torres. The winds originate in the Gulf of Lion and/or the Rhone Valley near Marseilles, France, and spread eastward to the Porto Torres area. Some northwesterly winds reaching the Port are not of true Mistral origin, but local personnel refer to all northwesterly winds as Mistral. Northwesterly winds which are not of Mistral origin are usually caused by low pressure systems moving eastward north of Sardinia.

The worst conditions at the Port are caused by strong northwesterly Mistral winds that are quite common during winter. They typically blow steadily for 24 to 48 hours with winds to 40 kt. The strongest events have maximum velocities of 75 kt. Although the pier area of the outer harbor is somewhat protected by Asinara Island, it still experiences waves of 6 ft (2 m) with 5 to 7 second periods. Swell waves typically develop during a strong northwesterly outbreak and may persist for up to 15 hours after the winds subside. The inner harbor is protected from northwesterly wave motion.

Most of the remainder of the bad weather at Porto Torres is caused by northeasterly winds. A typical strong outbreak will bring winds of 35 to 40 kt, with maximum velocities of 55 kt. The most common cause of strong northeasterly winds is a low pressure system which moves southeastward from the Gulf of Genoa across the Tyrrhenian Sea.

Precipitation occurs frequently throughout the winter season as transient low pressure systems and/or associated fronts move through the region. Although records are not available for Porto Torres, those for Sassari, located about 10 n mi southeast of the Port, show that precipitation frequency is greatest during November and December, with each of the months averaging 14 days with precipitation. Thunderstorms are infrequent and not very intense.

Temperature records for Porto Torres are not available, but winter temperatures are likely to approximate those of Guardiavecchia (on Isola La Maddalena, about 50 n mi northeast of Porto Torres). The extreme winter temperatures at Guardiavecchia ranged from about 30°F (-1°C) to 73°F (23°C) during a 5-year period of record. Although not cold by many standards, the lower range of the temperatures can produce wind chill values (temperatures combined with wind) that can adversely affect personnel working on weather decks. Table 3-1 can be used to determine wind chill for various temperature and wind combinations.

Table 3-1. Wind Chill. The cooling power of the wind expressed as "Equivalent Chill Temperature" (adapted from Kotsch, 1983).

Wind Speed		Cooling Power of Wind expressed as "Equivalent Chill Temperature"								
Knots	MPH	Temperature (°F)								
Calm	Calm	40	35	30	25	20	15	10	5	0
		Equivalent Chill Temperature								
3-6	5	35	30	25	20	15	10	5	0	-5
7-10	10	30	20	15	10	5	0	-10	-15	-20
11-15	15	25	15	10	0	-5	-10	-20	-25	-30
16-19	20	20	10	5	0	-10	-15	-25	-30	-35
20-23	25	15	10	0	-5	-15	-20	-30	-35	-45
24-28	30	10	5	0	-10	-20	-25	-30	-40	-50
29-32	35	10	5	-5	-10	-20	-30	-35	-40	-50
33-36	40	10	0	-5	-15	-20	-30	-35	-45	-55

B. <u>Spring (March through May)</u>

The spring season in the west-central Mediterranean region is relatively long, and is noted for "periods of stormy weather, with Mistral conditions that alternate with a number of false starts of settled summer-type weather" (Brody and Nestor, 1980). Mistral events occur through early May, but are strongest and most frequent earlier in the season. Low pressure systems continue to develop and move through the Gulf of Genoa and Tyrrhenian Sea, bringing occasional strong winds high seas and cloudy rainy conditions to the Porto Torres area. As with the Mistral outbreaks, strong northeasterly winds are most common early in the season, and are uncommon after early May. Springtime fog, while not common, can reduce early morning visibility to less than 2 miles on 1 or 2 days each year.

C. <u>Summer (June through September)</u>

Summer is a season of relatively settled weather at Porto Torres. The upper-level westerlies and the associated storm track have moved north of the Mediterranean Basin, so transient low pressure systems are uncommon. Mistral events may occur throughout the year, but are much weaker and more infrequent during the summer season. An afternoon sea breeze is common during summer, but is usually 10 kt or less.

Precipitation is at its yearly minimum during summer. July is the driest month of the year with only 1 day during an average month having precipitation.

D. <u>Autumn (October)</u>

The autumn season is short, as the transition from a summer weather regime to winter is abrupt in the northern Mediterranean region. Mistral frequency and intensity increases abruptly through the month. Northeasterly winds also become more common as transient low pressure systems again move through the area. Precipitation increases significantly during October, occurring on 12 days of an average month.

3.6 Harbor Protection

As detailed below, vessels utilizing the inner and outer harbors of the Port of Porto Torres are afforded limited protection from winds and waves. But ships in the anchorages, which are located outside the protective breakwater systems, are largely exposed and vulnerable to strong winds and high waves.

3.6.1 Wind and Weather

The inner harbor is exposed to the effects of wind and weather, but local authorities did not identify any problems with harbor operations. The outer harbor is also exposed, but wind alone causes few problems. It is the related wave action that causes difficulty. See paragraph 3.6.2 below. If wave conditions permit, ships moored in the Port can double mooring lines and remain moored during strong winds.

3.6.2 Waves

Northwesterly Mistral winds generate seas of about 6 ft (2 m), which cause ships berthed at Pontile S.I.R. No. 1 to pound against the pier. Once the Mistral winds start to blow, the waves near the harbor entrance make entering and leaving the Port dangerous. Winds from the northeast can also cause hazardous conditions. Therefore, the recommended course of action is to get underway and leave the pier or anchorage before the onset of the strong winds. It should be noted that there are only two tugs in Porto Torres and they may not be available after heavy weather sets in (FICEURLANT, 1987).

Northeasterly winds also raise seas, but the solid concrete construction of Pontile di Levante in the eastern part of the outer harbor protects Pontiles No. 1 and 2 from northeasterly waves. Ship pounding against piers 1 and 2 is not a problem during northeast winds.

3.7 Protective and Mitigating Measures

3.7.1 Sortie/Remain in Port

Ships moored in the inner harbor should find no need to sortie if strong winds are forecast. Mooring lines should be doubled. Ships moored in the outer harbor should get underway and leave the harbor prior to the onset of strong northwesterly Mistral winds, but should be able to remain at pierside with doubled mooring lines if northeasterly winds are forecast. Protection from winds and waves during a Mistral can be obtained by anchoring in the lee of Asinara Island. Anchoring near Asinara Island is normally prohibited, but the Port Captain will permit it during high wind situations.

3.7.2 Moving to a New Anchorage

Because of the exposure to strong northwest winds and high waves at the normal anchorage, ships are advised to weigh anchor and move to the lee of Asinara Island when strong northwesterly (Mistral) winds are forecast. Anchoring near Asinara Island is normally prohibited, but the Port Captain will permit it during high wind situations. Strong winds from the northeast pose a different problem. Since the waves will be fetch limited due to the restricted open water northeast of Porto Torres (about 50 n mi), it may be possible to remain in the anchorage during all but the strongest events by deploying a second anchor. If required to weigh anchor and leave the anchorage, relief from the high winds/ waves should be available in the lee of the high terrain of Corsica or Sardinia.

3.8 Local Indicators of Hazardous Weather Conditions

The following guidelines have been extracted from various sources and are intended to provide the insight necessary to enable the meteorologist to anticipate the onset, duration, intensity, and extent of hazardous weather conditions. Much of the following addresses Mistral winds, and is taken from Brody and Nestor's document, Regional Forecasting Aids for the Mediterranean Basin (1980).

3.8.1 Mistral (northwesterly) Winds

1. Local Indicator - Low clouds usually form on the hills of Asinara Island about 24 hours prior to the onset of strong northwesterly winds (Port Visit, 1988).

2. Causes - The Mistral is the result of a combination of the following factors:

(a) A basic circulation that creates a pressure gradient from west to east along the coast of southern France. This pressure gradient is normally associated with Genoa cyclogenesis.

(b) A fall wind effect caused by cold air associated with the Mistral moving downslope as it approaches the southern coast of France and thus increasing the wind speed.

(c) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia.

(d) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land).

Mistrals are observed in association with three particular upper level (500 mb) large-scale flow patterns. These flow patterns are classified as types A, B, and C by the British Air Ministry (1962).

Type A. A blocking ridge in the eastern Atlantic and a long-wave trough over Europe produces a strong northwesterly flow over western France. This is a meridional flow situation.

Type B. A blocking ridge extends northeastward from the eastern Atlantic over northern Europe and a low pressure belt covers the Mediterranean. Meridional flow predominates.

Type C. A series of depressions dominates the European mid-latitudes, and westerly winds prevail over the Mediterranean. This is a zonal-flow situation.

3. Onset - The following guidelines for forecasting the onset of a Mistral have been extracted from Brody and Nestor (1980). It is emphasized that they relate to Mistral outbreaks over the Gulf of Lion and/or the Rhone Valley near Marseilles. Not all Mistral winds will spread eastward to Porto Torres.

In association with a Type A large-scale flow pattern:

(a) Forecast the start of a Mistral within 48 hr when a surface frontal trough is located just south of Iceland and is backed by an extremely strong surge of cold air to the east of Greenland. (Note: The long-wave ridge axis is west of Iceland: this rule is biased toward established rather than developing patterns).

(b) Forecast the start of a Mistral within 24 hr when the frontal and 500 mb short-wave troughs extend across southern (or southeastern) England and the Bay of Biscay, and the short-wave ridge is located over Spain and France. (Note: The long-wave ridge axis is west of Iceland: This rule is biased toward established rather than developing patterns).

(c) A Mistral will occur if the 500 mb short-wave arrives over Perpignan (07747).

A Mistral is likely to occur with a Type A situation when: (1) the long wave trough is over or just past the south coast of France; and (2) a northwesterly (west through north-northeast) current with maximum speed of at least 50 kt at 500 mb is so oriented that it points toward the Gulf of Lion.

In association with a Type B large-scale flow pattern, forecast the start of a Mistral in 24 hr when; (1) the 500 mb trough moves over or just south of the south coast of France; and (2) the associated surface low appears in or near the Gulf of Genoa.

In association with a Type C large-scale flow pattern:

(a) Forecast the start of a Mistral within 48 hr when (1) a surface frontal trough and upper short-wave trough are 24° of longitude to the west of the Gulf of Lion, (2) the short-wave ridge is 12° west, and (3) both are progressing at a speed of 12° per day. (Note: The "rule of thumb" in this case is that these short-wave ridges and troughs replace each other in 24 hr, i.e., there is a tendency toward a 48 hr periodicity of frontal systems moving into France as long as the high-index circulation is maintained. Mistrals in this situation must be short-lived.

(b) Forecast the start of a Mistral within 24 hr when the surface and 500 mb short-wave troughs extend from the Irish Sea southward over Portugal, and the short-wave ridge is over southern France. (Note: The pattern is poorly defined in this high-index situation.)

(c) In association with a Type C large-scale flow pattern, a Mistral will occur if a deepening 500 mb trough moves over the south coast of France and is followed by a 500 mb ridge building at about the longitude of Ireland and Spain.

(d) In association with a Type C large-scale flow pattern, a Mistral will start when a northwesterly jet stream arrives over the Bay of Biscay.

The synoptic situations for the following guidelines vary.

(a) If a cutoff low as seen at 500 mb forms over northeast France and produces a northwesterly flow at 500 mb over the south coast, a Mistral may occur even though 500 mb wind speeds do not reach 50 kt and the jet axis is located far to the west and south.

(b) A Mistral generally sets in when the surface front or trough passes Perpignan (07747), or the 500 mb trough passes Bordeaux (07510). (Note: These two events are expected to occur nearly simultaneously.)

(c) Genoa lows occur almost simultaneously with the onset of the Mistral in the Gulf of Lion, and they invariably form when conditions are right for a Mistral to occur.

(d) If a 500 mb trough extends from central Europe southward over North Africa, a surface low from Algeria may propagate northward, intensify in the Gulf of Genoa, and initiate a Mistral.

(e) The Mistral will start when one of three differences is achieved: Perpignan (07747)-Marseille (07650), 3 mb; Marseille-Nice (07690), 3 mb; or Perpignan-Nice, 6 mb. A difference usually occurs from 0 to 24 hr after a closed Genoa low appears, but it occasionally occurs earlier.

(f) Wave clouds, such as observed on high-resolution Defense Meteorological Satellite Program (DMSP) satellite imagery, are observed over the Massif Central of southern France approximately 6 hr before the start of a Mistral.

(g) Lus La Croix Haute (07587) will provide a 2-3 hr advance notice of Mistral onset. This wind speed report will closely approximate the wind speed in the Gulf. (Note: Usefulness of this station is limited by the fact it only reports every 3 hr.)

(h) Orange (07579) gives a good 3-4 hr warning of a gale force Mistral when winds at this station increase to 25 kt northwesterly. Hourly reports are available from this station.

(i) By observing changes in the normally strong afternoon sea breeze (east-southeasterly) direction at Perpignan, it is possible to forecast the beginning of a Mistral in the Gulf of Lion. If, at this station, the wind shifts northerly with speeds increasing to 25-30 kt and the temperature drops at least 3°F, a strong Mistral (40-50 kt) will be blowing in the Gulf of Lion within 6 hr.

(j) The probability of Mistral occurrence is greatest (correlation coefficient, $r = 0.62$) if the 500 mb wind direction at Bordeaux is 330°-340° or 040°-050°, when the 500 mb trough reaches Nimes (07645). The probability decreases rapidly as direction changes either to the west or east from the 330°-050° band.

(k) The probability of Mistral occurrence with a blocking pattern is greatest (r = 0.30) if, at the time the trough reaches Nimes (07645), the Nimes height deviation from normal is about +200 m. For progressive systems, the probability increases from r = 0.26 for deviations of +75 to r = 0.98 for deviations of -350 m.

(l) The probability of Mistral occurrence is greatest when the 850 mb wind direction over Nimes is from 350°. It decreases with winds east or west of 350°, reaching near zero for winds from 240° and 090°.

(m) The probability of Mistral occurrence increases with the north component of the 850° mb wind at Nimes, reaching r = 0.93 for 50 kt.

4. <u>Intensity</u> - Although gusts of 70 kt in strong Mistral are experienced, the proportion of days when Mistral reaches gale force on the coast is small. At Perpignan and Marseille the number of days when Mistral reaches gale force is of the order of 10 to 15 in a year (Hydrographer of the Navy, 1963).

The following guidelines are extracted from Brody and Nestor (1980).

(a) Strongest winds associated with a Mistral do not occur until after the passage of the upper-level (500 mb) trough. This occurs well after the surface cold frontal passage.

(b) Forecast Mistral winds to increase during a Type A large-scale flow pattern aloft 24 hr after a new cold front or minor trough appears in the northwest current over southern England, and the maximum speed at 500 mb in the current increases at least 10 kt while the inflection point (IP) retrogrades or remains stationary; or with the passage of the new cold front or minor trough.

(c) Satellite observations indicating a strong Mistral will exhibit the following features: cloudy over France and clear over the water area south of the 1,000 ft water depth contour; clear over the Gulf of Lion but a cloud mass, parallel to the coast, lying 75-150 n mi offshore; wispy cloud streaks extending from 315° to 360° into offshore clouds. See NTAG Vol 2 pg 2D-8 (NEPRF, 1977) and NTAG Vol. 3 pg 2B-17 (NEPRF, 1980) for satellite case studies of Mistral events.

(d) Wave clouds extending from Sardinia to Tunisia, viewed on satellite imagery, are generally associated with gale force Mistral situations.

(e) Maximum Mistral winds occur when the surface isobars are at an angle of 30° to the valleys of either the Garonne, the Rhone or the Durance with low pressure to the southeast.

(f) Use the information below to estimate wind speed associated with a Mistral in the Gulf of Lion.

Pressure Difference (mb)	Perpignan* (station 07747) and Nice (station 07690)	Perpignan* and Marseille (station 07650)	Marseille** and Nice
3		30-35 kt	30-35 kt
4		40	40
5		45-50	45-50
6	30-35 kt		
8	40		
10	45-50		

* Highest pressure at Perpignan
** Highest pressure at Marseille

(g) A good indication of the intensity of a Mistral in the Gulf of Lion can be obtained by adding 10 kt to the wind speed reported by either Montpellier (07643) or Istres (07647).

(h) If the 500 mb winds reported at either Bordeaux (07510) or Brest (07110) are north-westerly at 65 kt or greater, storm warnings instead of gale warnings are indicated for the Gulf of Lion.

(i) Wind speeds over open water during a Mistral will be approximately double those measured at Perpignan or Marignane (Marseille) except in storm conditions, when the ratio will be lower.

5. Duration - The Mistral commonly lasts from 3 to 6 days but its duration may range from a few hours to 12 days or more. The most frequent length of a spell is about 3 1/2 days (Meteorological Office, 1962).

The following guidelines are taken from Brody and Nestor (1980).

In association with a Type A large-scale flow pattern, (described above under Mistral causes), surface winds usually decrease, i.e., the Mistral ceases, when the jet axis moves eastward and an anticyclonic regime is established. This rule reflects the control on the surface pattern that is exercised by the upper air pattern.

The Mistral will cease when the cyclonic regime at the surface gives way to an anticyclonic regime. Indications of this change are:

(a) The surface wind direction becomes north to northeast.

(b) The 500 mb ridge begins to move over the area.

(c) High pressure at the surface begins to move into the western basin of the Mediterranean.

(d) There is a change that reduces the pressure difference between France and the western basin.

Cold advection on the western flank of a blocking ridge over the eastern Atlantic may herald the breakdown of the long-wave pattern and, hence of the Mistral. This rule applies to Types A and B large-scale flow patterns where breakdown of the ridge, rather than eastward movement, results in cessation of the Mistral.

6. Extent - In the proximity of Marseille and the Rhone delta the local geography favors the Mistral, and this wind may develop here and produce what may be termed a "local Mistral" under a variety of pressure distributions which would not be conducive to the development of a "widespread" Mistral such as would affect the western Mediterranean generally. The orientation of the Rhone valley favors a northerly flow of air through the narrower parts. In the lower reaches the flow becomes northwesterly and this is the direction of the Mistral at Marseille. When the local Mistral is blowing, only the region around the Rhone delta, including Marseille, may be affected and the wind does not extend far (about 5 or 10 mi) to seaward. On other occasions, however, the Mistral may be widespread and may affect the whole of the Gulf of Lion and at times may extend even as far as the African coast and Malta. At such times it is common for the wind to be stronger in the Rhone delta-Marseille region than elsewhere. On many occasions light easterlies are reported from Nice when strong northwesterlies are blowing at Marseille (Hydrographer of the Navy, 1963).

Alongshore pressure gradient is important in predicting Mistral intensity. When the difference is small the Mistral will stop. When a 10 mb difference exists between Toulon and Nice, the Mistral will spread eastward. With only a 2 mb difference between Marseille and Toulon, the Mistral will cease near Toulon.

3.8.2 Northeasterly Winds

Since Mistral onset over the Gulf of Lion/Rhone Valley is usually coincident with the formation of a Genoa low, northeasterly winds may follow a north-westerly Mistral event at Porto Torres. If the Genoa low moves southeastward the wind at Porto Torres will veer from northwest to northeast.

The meteorologist should be alert for signs that a Genoa low is moving southeastward across the Tyrrhenian Sea. Such movement is associated with a strong anticyclone over the Balkans, Turkey and the Black Sea. It should be noted that even after the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean area, if a residual trough remains south of the Alps, new centers can develop and occasionally move southeast along the west coast of Italy. Another common occurrence is for a Genoa cyclone, which has been moving southeastward, to become stationary just west of southern Italy (Brody and Nestor, 1980). If the low has a large circulation, this situation may produce northeast winds over Porto Torres for an extended duration.

3.9 Summary of Problems, Actions, and Indicators

Table 3-2 is intended to provide easy-to-use seasonal references for meteorologists on ships using the Port of Porto Torres. Table 2-1 (Section 2) summarizes Table 3-2 and is intended primarily for use by ship captains.

Table 3-2. Potential problem situations at Port of Porto Torres - ALL SEASONS

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
1. Moored - Outer harbor. Strongest in Winter & early Spring Uncommon in Summer Also occurs in Autumn	a. NW'ly winds/waves - Locally called Mistral regardless of origin, the winds are responsible for 70% of the bad weather at the Port. A typical outbreak will bring winds of 40 kt, with a maximum of 70 kt. NW winds typically last 24-48 hr, but may last longer if of true Mistral origin. Waves in the outer harbor are usually 6 ft (2 m) with 5-7 second periods. Swell waves usually follow a strong outbreak, and may persist for up to 15 hr after winds subside, diminishing rapidly. Non-Mistral winds are most often caused by E moving transient low pressure systems passing N of Sardinia. Strong NW winds are most common during October-early May period.	a. Waves cause ships which are moored to Pontile S.I.R. No. 1 to pound against the pier. Ships should get underway and leave the Port prior to wind onset. Once the wind starts to blow, waves near the harbor entrance make entering and leaving the Port dangerous. (NOTE: There are only 2 tugs in Porto Torres and they may not be available once heavy weather sets in, so early action is necessary to ensure a safe departure.) Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.	a. (1) Local indicator - Low clouds usually form on the hills of Asinara Island about 24 hr prior to the onset of strong NW winds. (2) Other guidelines - There are many guidelines concerning the causes, onset, intensity, duration, and extent of NW Mistral winds. Refer to section 3.8.1 of the accompanying text for an extensive discussion.
Strongest in Winter & early Spring Uncommon in Summer Also occurs in Autumn	b. NE'ly winds/waves - Typical strong outbreak brings 35-40 kt winds, with 55 kt maximum. Waves are blocked from reaching Pontiles S.I.R. No. 1 and 2 by the solid concrete construction of Pontile di Levante. NE'ly winds are normally caused by low pressure systems moving SE from the Gulf of Genoa across the Tyrrhenian Sea. Most common during October-May period.	b. NE'ly waves are blocked from reaching Pontiles S.I.R. No. 1 and 2 by the solid concrete construction of Pontile di Levante, so leaving the Port is not necessary. Mooring lines should be doubled. Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.	b. Since Mistral onset over the Gulf of Lion/Rhone Valley is normally coincident with the formation of a Genoa low, NE winds will likely follow a NW Mistral at Porto Torres if the low moves SE. The meteorologist should be alert for signs that a Genoa low is moving SE across the Tyrrhenian Sea. Such movement is associated with a strong anticyclone over the Balkans, Turkey and the Black Sea. It should be noted that even after the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean area, if a residual trough remains S of the Alps, new centers can develop and occasionally move SE along the W coast of Italy. Another common occurrence is for a Genoa cyclone, which has been moving southeastward, to become stationary just W of southern Italy. If the low has a large circulation, this situation will produce NE winds over Porto Torres for an extended duration.
2. Moored - Inner harbor. Strongest in Winter & early Spring Uncommon in Summer Also occurs in Autumn	a. NW'ly winds/waves - Locally called Mistral regardless of origin, the winds are responsible for 70% of the bad weather at the Port. A typical outbreak will bring winds of 40 kt, with a maximum of 70 kt. NW winds typically last 24-48 hr, but may last longer if of true Mistral origin. Associated waves do not reach the inner harbor. Swell waves usually follow a strong outbreak, and may persist for up to 15 hr after winds subside, diminishing rapidly. Non-Mistral winds are most often caused by E moving transient low pressure systems passing N of Sardinia. Strong NW winds are most common during October-early May period.	a. Little effect on ships securely moored. Mooring lines should be doubled. Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.	a. (1) Local indicator - Low clouds usually form on the hills of Asinara Island about 24 hr prior to the onset of strong NW winds. (2) Other guidelines - There are many guidelines concerning the causes, onset, intensity, duration, and extent of NW Mistral winds. Refer to section 3.8.1 of the accompanying text for an extensive discussion.
Strongest in Winter & early Spring Uncommon in Summer Also occurs in Autumn	b. NE'ly winds/waves - Typical strong outbreak brings 35-40 kt winds, with 55 kt maximum. Waves reach the harbor entrance, and may propagate to the berths along Molo di Ponente. NE'ly winds are normally caused by low pressure systems moving SE from the Gulf of Genoa across the Tyrrhenian Sea. Most common during October-May period.	b. Little effect on ships securely moored. Mooring lines should be doubled. Personnel in exposed locations should be aware of the wind chill factor and dress appropriately.	b. Since Mistral onset over the Gulf of Lion/Rhone Valley is normally coincident with the formation of a Genoa low, NE winds will likely follow a NW Mistral at Porto Torres if the low moves SE. The meteorologist should be alert for signs that a Genoa low is moving SE across the Tyrrhenian Sea. Such movement is associated with a strong anticyclone over the Balkans, Turkey and the Black Sea. It should be noted that even after the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean area, if a residual trough remains S of the Alps, new centers can develop and occasionally move SE along the W coast of Italy. Another common occurrence is for a Genoa cyclone, which has been moving southeastward, to become stationary just W of southern Italy. If the low has a large circulation, this situation will produce NE winds over Porto Torres for an extended duration.

Table 3-2. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
3. Anchored - Outside breakwaters. OR Arriving/departing. Strongest in Winter & early Spring Uncommon in Summer Also occurs in Autumn	a. NW'ly winds/waves - Locally called Mistral regardless of origin, the winds are responsible for 70% of the bad weather at the Port. A typical outbreak will bring winds of 40 kt, with a maximum of 70 kt. NW winds typically last 24-48 hr, but may last longer if of true Mistral origin. Open sea waves reach 15 to 20 ft (4.5 to 6m). Swell waves may persist for up to 15 hr after winds subside, then diminish rapidly. Non-Mistral winds are most often caused by E moving transient low pressure systems passing N of Sardinia. Strong NW winds are most common during October-early May period.	a. Anchorages and entrance area exposed to open sea conditions. Ships at anchor should consider moving to lee of Asinara Island, anchorage there normally prohibited but Port Captain permits it during strong NE wind events. Departures should be made in advance of onset of strong winds, arriving vessels should make temporary anchorage in lee of Asinara Island. Limited tug availability compounds vessel movement during high winds. Appropriate dress may be required due to wind chill factor.	a. (1) Local indicator - Low clouds usually form on the hills of Asinara Island about 24 hr prior to the onset of strong NW winds. (2) Other guidelines - There are many guidelines concerning the causes, onset, intensity, duration, and extent of NW Mistral winds. Refer to section 3.8.1 of the accompanying text for an extensive discussion.
Strongest in Winter & early Spring Uncommon in Summer Also occurs in Autumn	b. NE'ly winds/waves - Typical strong outbreak brings 35-40 kt winds, with 55 kt maximum. Associated waves reach the anchorages. NE'ly winds are normally caused by low pressure systems moving SE from the Gulf of Genoa across the Tyrrhenian Sea. Most common during October-May period.	b. Anchorages and entrance area exposed to open sea conditions. Due to limited fetch to NE (about 50 n mi) wave conditions not as extreme as under NW winds, extreme NE wind speeds also lower than NW speeds. Anchored vessels should deploy second anchor or move to lee of Corsica or Sardinia. Inbound/outbound vessels be aware of limited tug availability and hazardous wind and wave conditions near entrance.	b. Since Mistral onset over the Gulf of Lion/Rhone Valley is normally coincident with the formation of a Genoa low, NE winds will likely follow a NW Mistral at Porto Torres if the low moves SE. The meteorologist should be alert for signs that a Genoa low is moving SE across the Tyrrhenian Sea. Such movement is associated with a strong anticyclone over the Balkans, Turkey and the Black Sea. It should be noted that even after the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean area, if a residual trough remains S of the Alps, new centers can develop and occasionally move SE along the W coast of Italy. Another common occurrence is for a Genoa cyclone, which has been moving southeastward, to become stationary just W of southern Italy. If the low has a large circulation, this situation will produce NE winds over Porto Torres for an extended duration.
4. Small boats. Strongest in Winter & early Spring Uncommon in Summer Also occurs in Autumn	a. NW'ly winds/waves - Locally called Mistral regardless of origin, the winds are responsible for 70% of the bad weather at the Port. A typical outbreak will bring winds of 40 kt, with a maximum of 70 kt. NW winds typically last 24-48 hr, but may last longer if of true Mistral origin. Waves in the outer harbor and anchorages are usually 6 ft (2 m) with 5-7 second periods, but do not reach the inner harbor. Swell waves usually follow a strong outbreak, and may persist for up to 15 hr after winds subside, diminishing rapidly. Non-Mistral winds are most often caused by E moving transient low pressure systems passing N of Sardinia. Strong NW winds are most common during October-early May period.	a. Operations in the inner harbor should be able to continue, but runs outside the harbor entrance should be curtailed until conditions abate. Boat personnel should be aware of the wind chill factor and dress appropriately.	a. (1) Local indicator - Low clouds usually form on the hills of Asinara Island about 24 hr prior to the onset of strong NW winds. (2) Other guidelines - There are many guidelines concerning the causes, onset, intensity, duration, and extent of NW Mistral winds. Refer to section 3.8.1 of the accompanying text for an extensive discussion.
Strongest in Winter & early Spring Uncommon in Summer Also occurs in Autumn	b. NE'ly winds/waves - Typical strong outbreak brings 35-40 kt winds, with 55 kt maximum. Waves reach the anchorage areas, and may propagate to berths along Molo di Ponente, but are blocked from reaching Pontiles S.I.R. No. 1 and 2 by the solid concrete construction of Pontile di Levante. NE'ly winds are normally caused by low pressure systems moving SE from the Gulf of Genoa across the Tyrrhenian Sea. Most common during October-May period.	b. Operations in the inner harbor should be able to continue, but runs outside the harbor entrance should be curtailed until conditions abate. Boat personnel should be aware of the wind chill factor and dress appropriately.	b. Since Mistral onset over the Gulf of Lion/Rhone Valley is normally coincident with the formation of a Genoa low, NE winds will likely follow a NW Mistral at Porto Torres if the low moves SE. The meteorologist should be alert for signs that a Genoa low is moving SE across the Tyrrhenian Sea. Such movement is associated with a strong anticyclone over the Balkans, Turkey and the Black Sea. It should be noted that even after the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean area, if a residual trough remains S of the Alps, new centers can develop and occasionally move SE along the W coast of Italy. Another common occurrence is for a Genoa cyclone, which has been moving southeastward, to become stationary just W of southern Italy. If the low has a large circulation, this situation will produce NE winds over Porto Torres for an extended duration.

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PORT VISIT INFORMATION

MAY 1988. NEPRF Meteorologists R. Fett and D. Perryman met with the Porto Torres Harbor Office Technical Officer, Captain Nicola Del Nobile, to obtain much of the information included in this port evaluation.

APPENDIX A

General Purpose Oceanographic Information

This section provides some general definitions regarding waves and is extracted from H.O. Pub. No. 603, Practical Methods for Observing and Forecasting Ocean Waves (Pierson, Neumann, and James, 1955).

Definitions

Waves that are being generated by local winds are called "SEA". Waves that have traveled out of the generating area are known as "SWELL". Seas are chaotic in period, height and direction while swell approaches a simple sine wave pattern as its distance from the generating area increases. An in-between state exists for a few hundred miles outside the generating area and is a condition that reflects parts of both of the above definitions. In the Mediterranean area, because its fetches and open sea expanses are limited, SEA or IN- BETWEEN conditions will prevail. The "SIGNIFICANT WAVE HEIGHT" is defined as the average value of the heights of the one-third highest waves. PERIOD and WAVE LENGTH refer to the time between passage of, and distances between, two successive crests on the sea surface. The FREQUENCY is the reciprocal of the period (f = 1/T) therefore as the period increases the frequency decreases. Waves result from the transfer of energy from the wind to the sea surface. The area over which the wind blows is known as the FETCH, and the length of time that the wind has blown is the DURATION. The characteristics of waves (height, length, and period) depend on the duration, fetch, and velocity of the wind. There is a continuous generation of small short waves from the time the wind starts until it stops. With continual transfer of energy from the wind to the sea surface the waves grow with the older waves leading the growth and spreading the energy over a greater range of frequencies. Throughout the growth cycle a SPECTRUM of ocean waves is being developed.

A Beaufort Scale table with related wave effects is shown on the following page.

BEAUFORT SCALE

Beaufort Number	Wind Speed Knots	Wind Speed MPH	Seaman's term	Effects observed at sea	Term and height of Waves in meters
0	Under 1	Under 1	Calm	Sea like mirror.	Calm, glassy, 0
1	1-3	1-3	Light air	Ripples with appearance of scales; no foam crests.	
2	4-6	4-7	Light breeze	Small wavelets; crests of glassy appearance, not breaking	Rippled, less than 0.5
3	7-10	8-12	Gentle breeze	Large wavelets; crests begin to break; scattered whitecaps.	Smooth, 0.5
4	11-16	13-18	Moderate breeze	Small waves, becoming longer; numerous whitecaps.	Slight, 1.0
5	17-21	19-24	Fresh breeze	Moderate waves, taking longer form; many whitecaps; some spray.	Moderate, 1.0-2.5
6	22-27	25-31	Strong breeze	Larger waves forming; whitecaps everywhere; more spray.	Rough, 2.5-4.0
7	28-33	32-38	Moderate gale	Sea heaps up; white foam from breaking waves begins to be blown up in streaks.	Very rough, 4.0-6.0
8	34-40	39-46	Fresh gale	Moderate high waves; edges of crests begin to break; foam is blown in steaks.	
9	41-47	47-54	Strong gale	High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility.	
10	48-55	55-63	Whole gale	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced.	High, 6.0-9.0
11	56-63	64-72	Storm	Exceptionally high waves; sea covered with white foam patches; visibility still more reduced.	Very high, 9.0-13.5
12	64-71	73-82	Hurricane	Air filled with foam; sea completely white with driving spray; visibility greatly reduced. Winds of force 12 and above very rarely experienced on land; usually accompanied by widespread damage.	Phenomenal, greater than 13.5
13	72-80	83-92			
14	81-89	93-103			
15	90-99	104-114			
16	100-108	115-125			
17	109-118	126-136			

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29Q	Submarine LANT SSBN
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